



Assessment of state-of-the-art dust emission scheme in GEOS

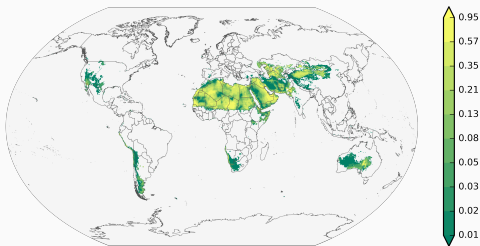
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Dust emissions in GEOS

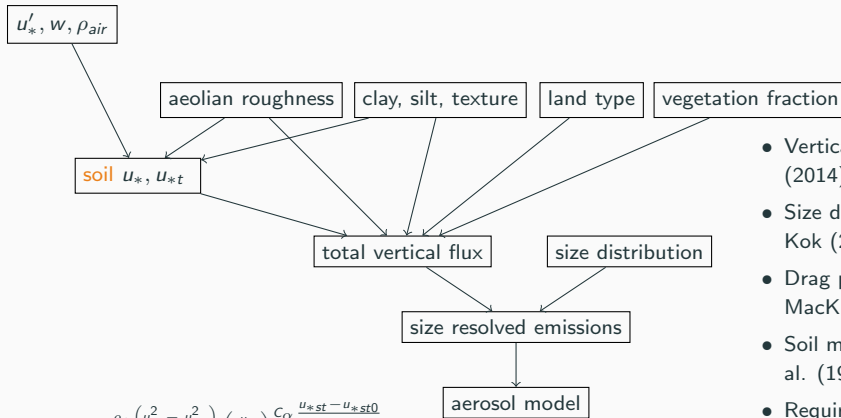


The source function (S) used in GEOS.

- Emissions are calculated for the five GOCART dust size bins: $F_i = CSs_i u_{10}^2 (u_{10} - u_{t,i})$
- Follows the empirical formulation of Gillette and Passi (1988)
- Relies on topographic source function
- Driven by 10-meter winds
- Size dependent threshold velocity modulated by soil moisture content

Motivation and objectives

- The Ginoux scheme works remarkably well in GEOS, but can we improve further the model performance by implementing a physically based emission scheme?
- Investigate the performance of Kok et al. (2014) scheme in GEOS.



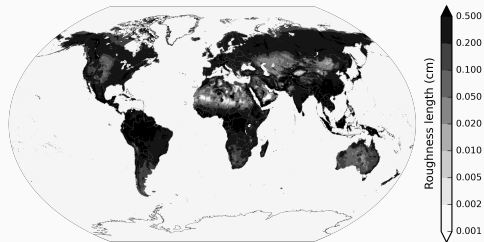
- Vertical dust flux: Kok et al. (2014)
- Size distribution of emitted dust: Kok (2011)
- Drag partition correction: MacKinnon et al. (2004)
- Soil moisture correction: Fecan et al. (1999)
- Requires static and dynamic global datasets
- Low numerical complexity and cost

$$F_d = C_d f_{bare} \gamma \frac{\rho_a (u_*^2 - u_{*t}^2)}{u_{*st}} \left(\frac{u_*}{u_{*t}} \right) C_{\alpha} \frac{u_{*st} - u_{*st0}}{u_{*st0}}$$

$$C_d = C_{d0} \exp \left(-C_e \frac{u_{*st} - u_{*st0}}{u_{*st0}} \right), \quad u_{*st} = u_{*t} \sqrt{\frac{\rho_a}{\rho_{a0}}}$$

Methodology

- GEOS AGCM was run at $50\text{km} \times 50\text{km}$ horizontal resolution
- MERRA2 meteorology and prescribed SST for 2015
- GOCART aerosols
- Radiatively interactive aerosols
- **Control** - standard dust emissions (Ginoux et al., 2001)
- **K14(a)** - K14 dust emissions (Kok et al., 2014)
- **K14(b)** - K14 scheme and ARLEMS surface roughness over bare or sparsely vegetated surface



ARLEMS aeolian aerodynamic roughness length derived from ASCAT backscattering and PARASOL protrusion coefficient at 865nm (Prigent et al., 2012).

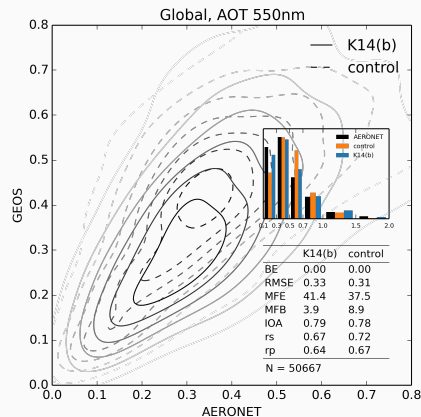
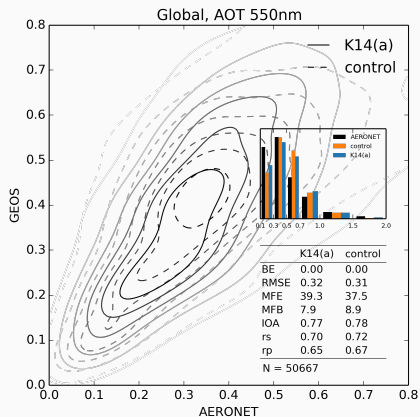
MERRA2: aerosol analysis AOT(550)

GEOS: $DOD(550)/AOD(550) > 0.8$

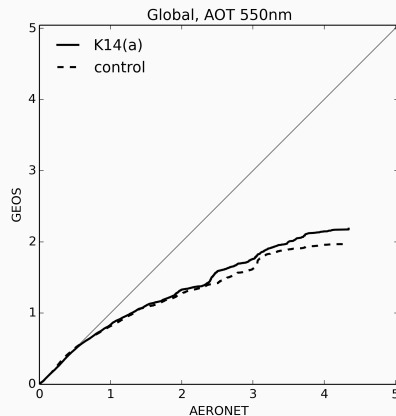
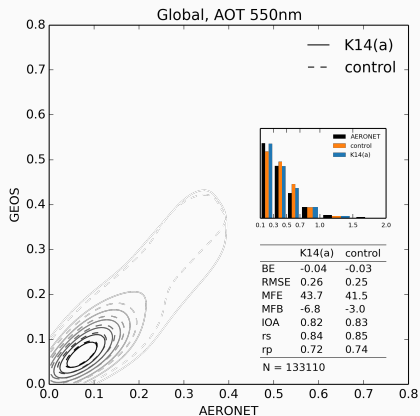


AERONET sites with **dusty** observations. Sites with more than 2% of the total number of dusty observations in 2015 are labeled.

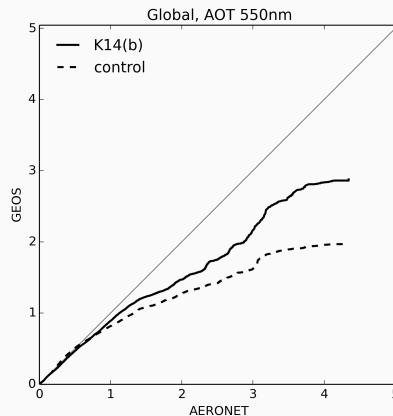
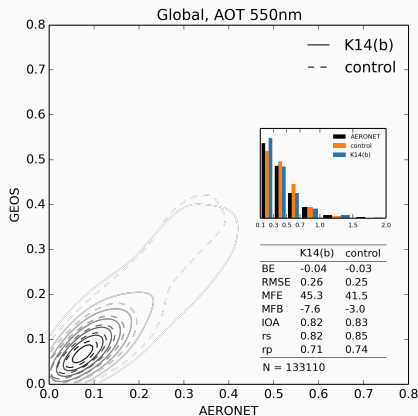
Results



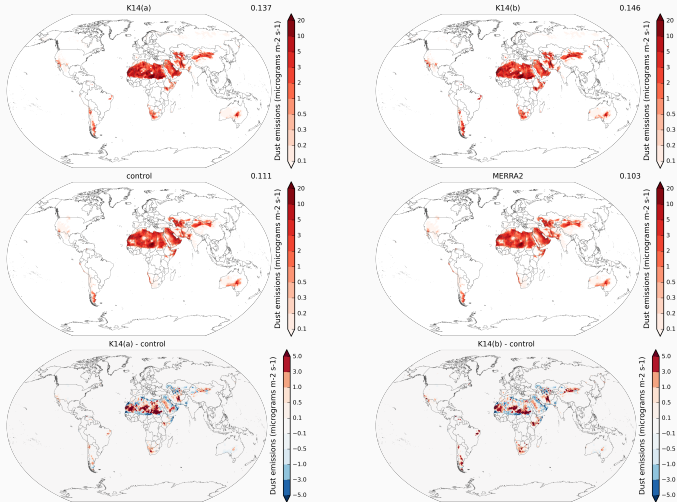
The skills of the K14 modeling experiments are lower but comparable to the control.



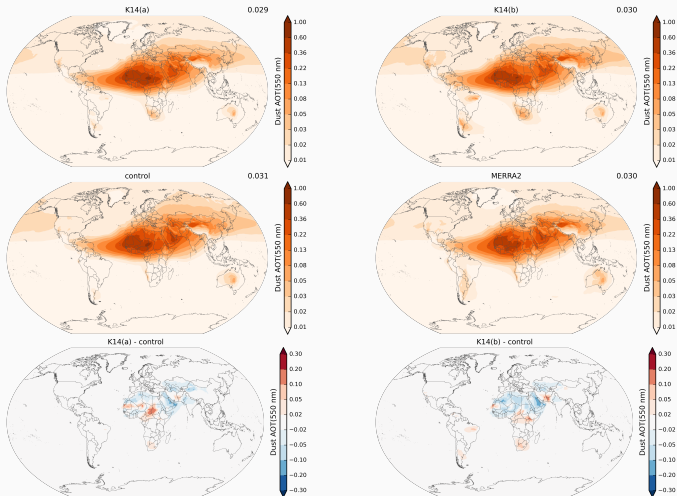
The control and the K14(a) experiment are unable to reproduce the dispersion in the AERONET data.



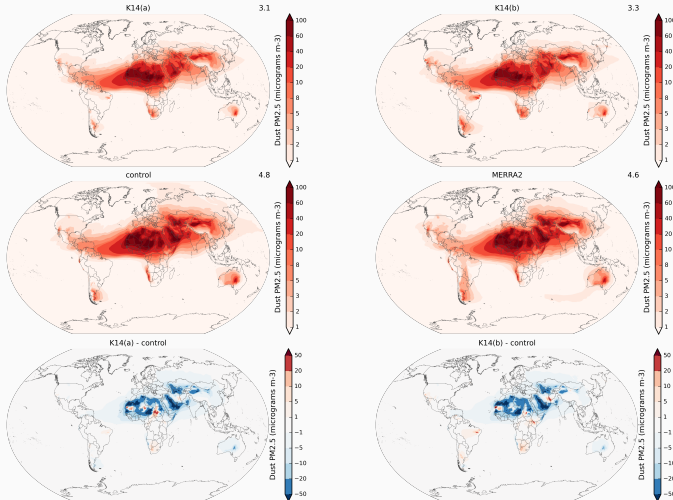
The distribution of AOT in the K14(b) is similar to the observations, however occurrences of AOT > 1.5 remain underpredicted in the model.



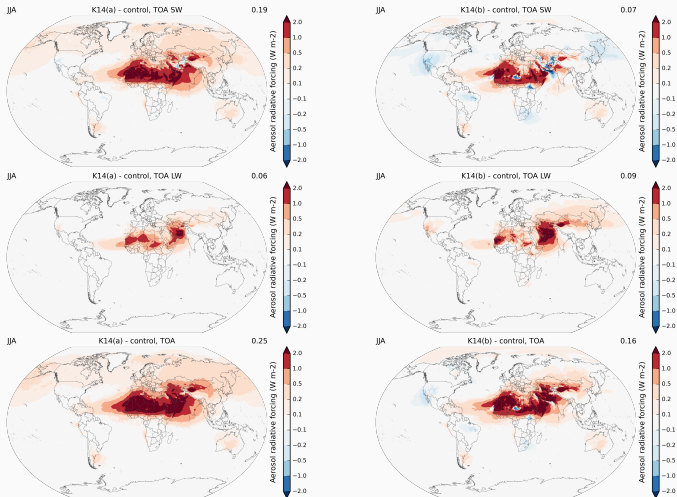
- The major dust sources are represented well in the control and the K14 experiment
- Global emissions:
 - control = 1800 Tg/yr
 - K14(a) = 2200 Tg/yr (+20%)
 - K14(b) = 2350 Tg/yr (+30%)
- South America (Patagonia and Sertao), Southern Africa (Kalahari, Namib, Karoo), Sahel and Gobi sources are more active in the K14 experiments



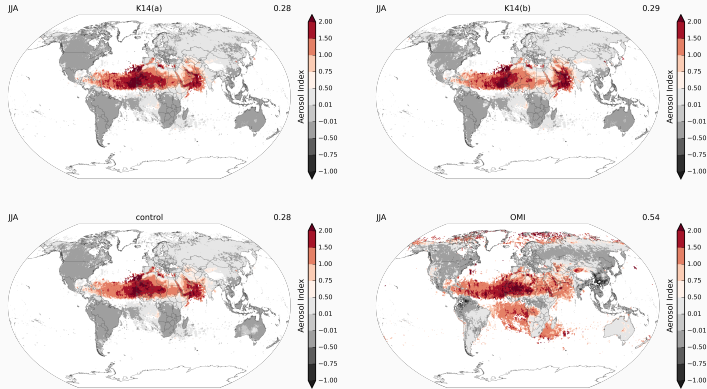
- The control and the two K14 experiments have similar global dust AOT
- Recent estimate (Ridley et al., 2016) of global dust AOT are 0.030 ± 0.005
- The K14 runs have lower dust AOT in the Northern Hemisphere and higher dust AOT in the Southern Hemisphere.



- Dust PM2.5 is generally higher in the control than in the K14 experiments
- In the K14 experiments, countries downwind of dust sources in Sahara and the Middle East are exposed to smaller amount of harmful fine dust particles



- There is less SW cooling (more heating over bright surfaces) at TOA in the K14 experiments
- There is more LW heating at TOA in the K14 experiments



- The control and K14(a) reproduce very well the OMI data in the regions affected by Saharan dust
- AI is overpredicted over the Middle East in the three experiments
- AI is underpredicted in Taklamakan and Australia

Conclusions

- The Kok et al. (2014) scheme was implemented in GEOS
- The performance of the new dust emission scheme was found to be very similar to that of the default parameterization based on Ginoux et al. (2001)
- Noticeable differences were observed in the predicted dust emissions, PM2.5 and radiative effect of dust at TOA - we attribute these differences primarily to the coarser size distribution of emitted dust in the K14 scheme.
- The results obtained with the newly implemented K14 scheme are encouraging
- We plan to analyze and fine tune the K14 emissions on a regional level



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Project: Constraining the Modeling of Dust Aerosol and Climate Impacts Using CALIPSO, CloudSat, and Other A-Train Satellite Measurements

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Questions?

Backup slides

